CLAIMS

What is claimed is:

1. An optical tuning apparatus, comprising:

(a) a first tunable wavelength selection element positioned in a light beam and having a first adjustable free spectral range; and

(b) a second tunable wavelength selection element positioned in said light beam and having a second adjustable free spectral range;

(c) said first and second tunable wavelength selection elements configured to define a joint free spectral range operable to tune said light beam.

2. The apparatus of claim 1, wherein said first and second tunable wavelength selection elements define a joint transmission peak that is adjustable according to tuning of said first and second tunable wavelength selection elements.

3. The apparatus of claim 1, further comprising a gain medium having first and second facets and emitting said light beam from said first facet, said gain medium having a free spectral range.

4. The apparatus of claim 3, wherein said joint free spectral range is at least as great as a gain bandwidth of said gain medium.

5. The apparatus of claim 3, wherein said first free spectral range is approximately equal to a multiple of said gain medium free spectral range.

6. The apparatus of claim 5, wherein said second free spectral range is approximately equal to a multiple of said gain medium free spectral range.

7. The apparatus of claim 3, further comprising a reflective element positioned in said light beam after first and second tunable wavelength selection elements, said reflective element and said second facet of said gain medium defining an external cavity laser.

8. The apparatus of claim 1, wherein said first and second tunable wavelength selection elements comprise at least one etalon.

9. The apparatus of claim 1, wherein said first and second tunable wavelength selection elements comprise at least one grating.

10. The apparatus of claim 1, wherein said first and second tunable wavelength selection elements comprise first and second etalons.

11. The apparatus of claim 10, wherein at least one of said first and second etalons is thermo-optically tunable.

12. The apparatus of claim 10, wherein at least one of said first and second etalons is electro-optically tunable.

13. The apparatus of claim 10, wherein at least one of said first and second etalons is angle tuned.

14. The apparatus of claim 10, wherein at least one of said etalons comprises a semiconductor material.

15. The apparatus of claim 10, wherein at least one of said etalons includes first and second surfaces, each said surface having at least one quarter wave dielectric pair layer thereon.

16. The apparatus of claim 14, wherein said etalon includes a thermal control element integrated thereon.

17. The apparatus of claim 11, wherein said etalon is operatively coupled to a thermal controller.

18. The apparatus of claim 11, wherein said etalon is operatively coupled to a thermal reservoir.

19. A tuning apparatus for a light beam, comprising

(a) a first tunable wavelength selection element positioned in said light beam, said first tunable element configured to define a first plurality of transmission peaks;

(b) a second tunable wavelength selection element positioned in said light beam, said second tunable element configured to define a second plurality of transmission peaks;

(c) said first and second pluralities of transmission peaks defining a single joint transmission peak within a selected wavelength range; and

(d) said first and second tunable wavelength selection elements operable to adjust said joint transmission peak according to adjustment of said first and second tunable elements.

20. The apparatus of claim 19, further comprising a gain medium having first and second facets and emitting said light beam from said first facet, said gain medium having a free spectral range.

21. The apparatus of claim 20, further comprising a reflective element positioned in said light beam after first and second tunable wavelength selection elements, said reflective element and said second facet of said gain medium defining an external cavity laser.

22. The apparatus of claim 20, wherein said first tunable wavelength selection element has a first free spectral range that is approximately equal to a multiple of said gain medium free spectral range.

23. The apparatus of claim 20, wherein said second tunable wavelength selection element has a second free spectral range that is approximately equal to a multiple of said gain medium free spectral range.

24. The apparatus of claim 20, wherein said joint free spectral range is at least as great as a gain bandwidth of said gain medium.

25. The apparatus of claim 19, wherein said first and second tunable wavelength selection elements comprise at least one etalon.

26. The apparatus of claim 19, wherein said first and second tunable wavelength selection elements comprise at least one grating.

27. The apparatus of claim 19, wherein said first and second tunable wavelength selection elements comprise first and second tunable etalons.

28. The apparatus of claim 27, wherein at least one of said first and second tunable etalons is thermo-optically tunable.

29. The apparatus of claim 27, wherein at least one of said first and second tunable etalons is electro-optically tunable.

30. The apparatus of claim 27, wherein at least one of said first and second tunable etalons is angle tuned.

31. The apparatus of claim 27, wherein at least one of said tunable etalons comprises a semiconductor material.

32. The apparatus of claim 27, wherein at least one of said tunable etalons includes first and second surfaces, each said surface having at least one quarter wave dielectric pair layer thereon.

33. The apparatus of claim 31, wherein said tunable etalon includes a thermal control element integrated thereon.

34. The apparatus of claim 28, wherein said tunable etalon is operatively coupled to a thermal controller.

35. The apparatus of claim 28, wherein said tunable etalon is operatively coupled to a thermal reservoir.

36. A laser apparatus, comprising:

(a) a gain medium emitting a light beam;

(b) a first tunable wavelength selection element positioned in said light beam and having a first adjustable free spectral range;

(c) a second tunable wavelength selection element positioned in said light beam and having a second adjustable free spectral range; and

(d) said first and second tunable wavelength selection elements defining a joint free spectral range with a single joint transmission peak within a selected wavelength range, said single joint transmission peak adjustable in phase according to tuning of said first and second tunable wavelength selection elements.

37. The apparatus of claim 36, wherein said joint free spectral range is at least as great as a gain bandwidth of said gain medium.

38. The apparatus of claim 37, wherein said first free spectral range is approximately equal to a multiple of a free spectral range of said gain medium.

39. The apparatus of claim 38, wherein said second free spectral range is approximately equal to a multiple of said gain medium free spectral range.

40. A method for tuning a light beam, comprising:

(a) positioning a first tunable wavelength selection element in said light beam, said first tunable wavelength selection element having a first adjustable free spectral range;

(b) positioning a second tunable wavelength selection element in said light beam, said second tunable element having a second adjustable free spectral range;

(c) defining a joint free spectral range from said first and second free spectral ranges; and

(d) adjusting said joint free spectral range by tuning said first and second tunable wavelength selection elements.

41. The method of claim 40, wherein said defining said joint free spectral range comprises defining a single joint transmission peak within a selected wavelength range.

42. The method of claim 41, wherein said adjusting said joint free spectral range comprises adjusting said joint transmission peak.

43. The method of claim 40, further comprising:

(a) providing a gain medium having first and second facets;

(b) emitting said light beam from said first facet; and

(c) positioning a reflective element in said light beam after said first and second tunable wavelength selection elements, said reflective element and said second facet of said gain medium defining an external laser cavity.

44. The method of claim 43, wherein said joint free spectral range is at least as great as a gain bandwidth of said gain medium.

45. The method of claim 43, wherein said first free spectral range is approximately equal to a multiple of a free spectral range of said gain medium.

46. The method of claim 45, wherein said second free spectral range is approximately equal to a multiple of said gain medium free spectral range.

47. The method of claim 40, wherein:

(a) said positioning said first tunable wavelength selection element comprises positioning a first tunable etalon in said light beam; and

(b) said positioning said second tunable wavelength selection element comprises positioning a second tunable etalon in said light beam.

48. The method of claim 47, wherein said adjusting said joint free spectral range comprises thermo-optically tuning said first and second tunable etalons.

49. The method of claim 48, wherein said thermo-optically tuning comprises;

(a) thermally adjusting a refractive index of said first tunable etalon; and

(b) thermally adjusting a refractive index of said second tunable etalon.

50. The method of claim 49, wherein said thermo-optically tuning further comprises;

(a) thermally adjusting physical thickness of said first tunable etalon; and

(b) thermally adjusting physical thickness of said second tunable etalon.

51. A method for laser operation, comprising:

(a) emitting a light beam from a first facet of a gain medium:

(b) positioning an end reflector in said light beam, said end reflector and a second facet of said gain medium defining an external laser cavity;

(c) positioning first and second tunable wavelength selection elements in said light beam before said end reflector, said first and second tunable wavelength selection elements respectively configured to define first and second pluralities of transmission peaks;

(d) defining a single joint transmission peak from said first and second pluralities of transmission peaks; and

(e) adjusting said joint transmission peak by tuning said first and second tunable wavelength selection elements.

52. A laser apparatus, comprising:

(a) gain means for emitting a light beam; and

(b) first and second tunable means for wavelength selection of said light beam by Vernier effect.

53. The apparatus of claim 52, further comprising means for defining an external laser cavity, said first and second tuning means positioned in said external laser cavity.

54. The apparatus of claim 52, wherein said first and second tunable means comprise first and second thermo-optic etalon means for wavelength selection of said light beam.